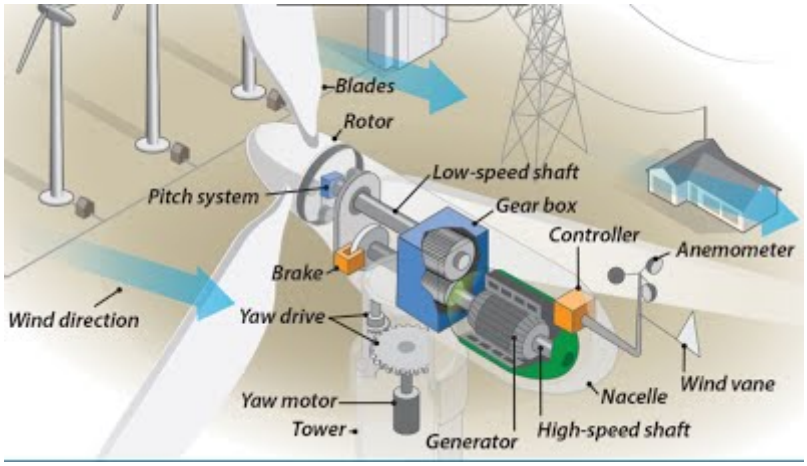
Causes of Wind Turbine Failure

- gearbox, blade, mechanical, weather issues
    - bearings within the gearboxes are the biggest issue
    - 48 million euros worth of bearing replacements and inspections in a single year
        - Approx $52,960,800.00
- Main components of a wind turbine:



- "catastrophic gear box failures appear to be caused primarily by induced mechanical voltage straying through the gearbox, pitting the bearings".
    - []: https://sites.google.com/site/metropolitanforensics/cause-and-contributing-factors-of-failure-of-wind-turbines "CAUSE AND CONTRIBUTING FACTORS OF FAILURE OF GEARED WIND TURBINES"
- Other risk factors:
    - Lightning strikes
    - Wind load
        - The force on a structure arising from the impact of wind on it.
    - Excessive vibration
    - Voltage irregularities
    - Converter failure
    - Overspeed that results in burning of the windings

- Most frequent causes of generator failure (in order of frequency):
    - For generators that are less than 1,000-kW:
        - Damage to rotor
        - Damage to stator
            - A stationary part of a rotational generator
        - Damage to bearings
        - Damage to collector rings
    - For generators that are between 1,000- and 2,000-kW:
        - Damage to bearings

        - Damage to collector rings
        - Damage to rotor
        - Damage to stator
        - Damage to cooling system
        - Damage to rotor leads
    - For generators that were greater than 2,000-KW:
        - Damage to bearings
        - Damage to stator
        - Damage to stator wedge
        - Damage to rotor
        - Damage to rotor leads
        - Damage to collector rings

- Main causes of turbine blade failure:
    - Lightning strikes
        - "fiberglass material immediately surrounding the lightning attachment location becomes damaged due to plastic deformation"
    - Foreign object damage (birds?)
    - Poor design
    - Material failure
    - Power regulator failure
- "Accumulations of bugs, oil, and ice on the blades will also reduce power as much as 40%"
- "At the cut-in wind speed, the blades start to turn and a trickle of electricity starts to be produced. Around cut-in, the generator may be used as a motor to help the wind overcome inertia and start the blades turning.

  The cut-in speed is typically 7 to 9 mph.

  At the rated wind speed, the turbine is able to generate electricity at its maximum, or rated, capacity.

  The rated speed is usually in the range of 25 to 35 mph.

  At the cut-out wind speed, the turbine shuts down to avoid damage. The pitch controllers feather the blades to let the wind flow past them and the rotor hub is braked. The wind usually has to return to a much lower speed, called the cut-back-in wind speed, for a certain amount of time before the turbine will restart.

  The cut-out speed is generally around 55 mph. The cut-back-in speed is around 45 mph."
    - []: https://www.wind-watch.org/faq-technology.php "National Wind Watch Tech FAQ"